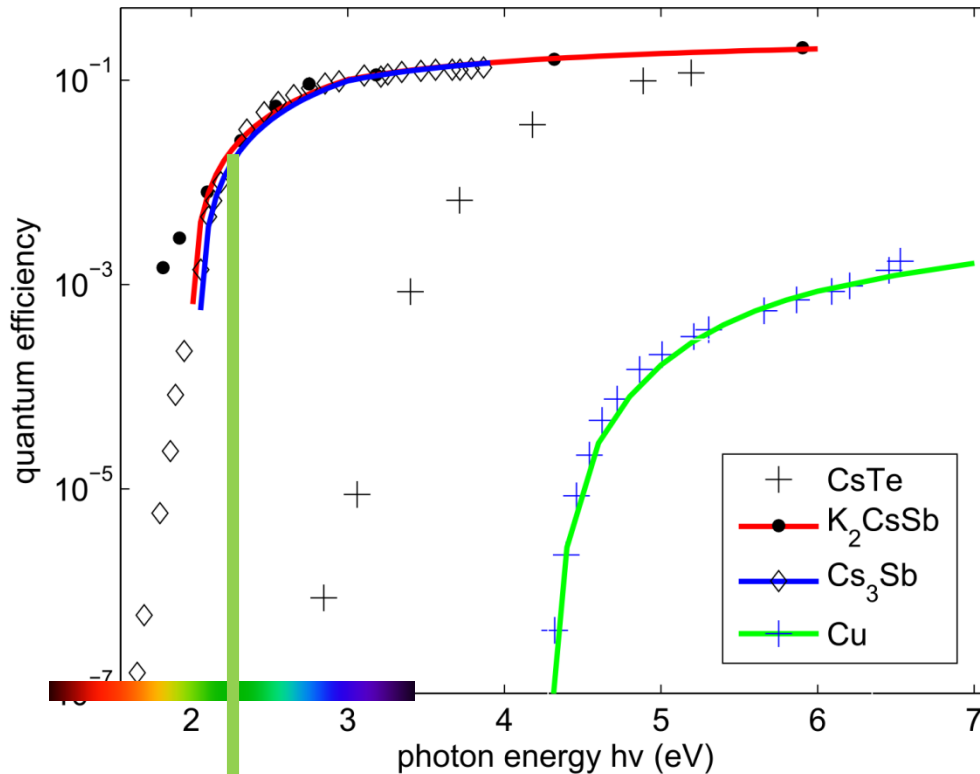


CsK₂Sb PHOTOCATHODE DEVELOPMENT FOR bERLinPro

Martin Schmeißer, Julius Kühn, Thorsten Kamps, Andreas Jankowiak
Helmholtz-Zentrum Berlin



532nm available as 2. harmonic of Nd or Yb lasers

Photoinjector for bERLinPro

Aim:

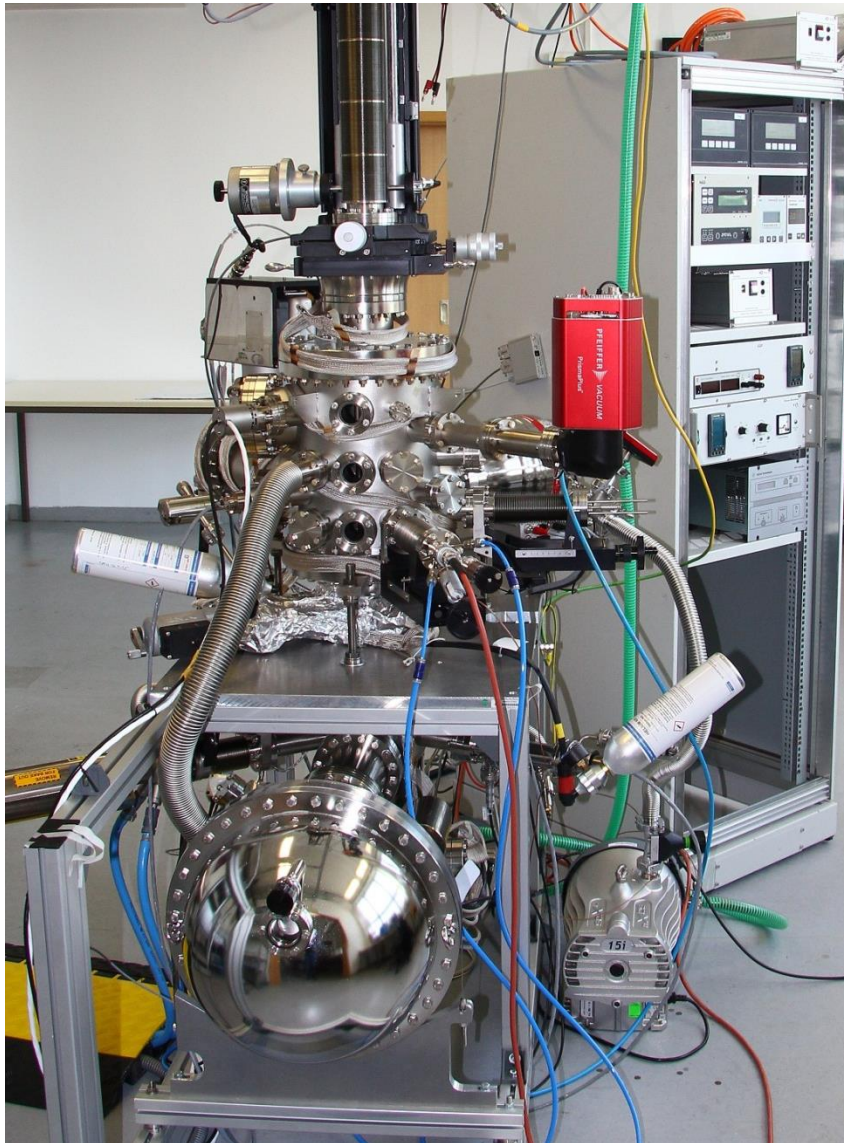
- 0.5 mm mrad emittance from gun
- 100mA in cw operation
- 2ps rms bunch length

Boundary conditions

- 1% QE at 532nm requires 23W average laser power on the cathode

$$P_{\text{laser}} = \frac{124 \text{ W nm}}{\lambda \cdot \text{QE}}$$

- High-QE semiconductors are highly reactive, survive only in 10⁻¹⁰ mbar vacuum



Preparation chamber:

- effusion cell for Sb, dispenser sources for K and Cs
- co-deposition of K and Cs or K and Sb

Quantum efficiency:

- Spectral response
- Spatial distribution

Intrinsic Emittance:

- Resolved in a drift-space spectrometer - Momentatron

See IPAC14 mopri019

Surface Analysis chamber:

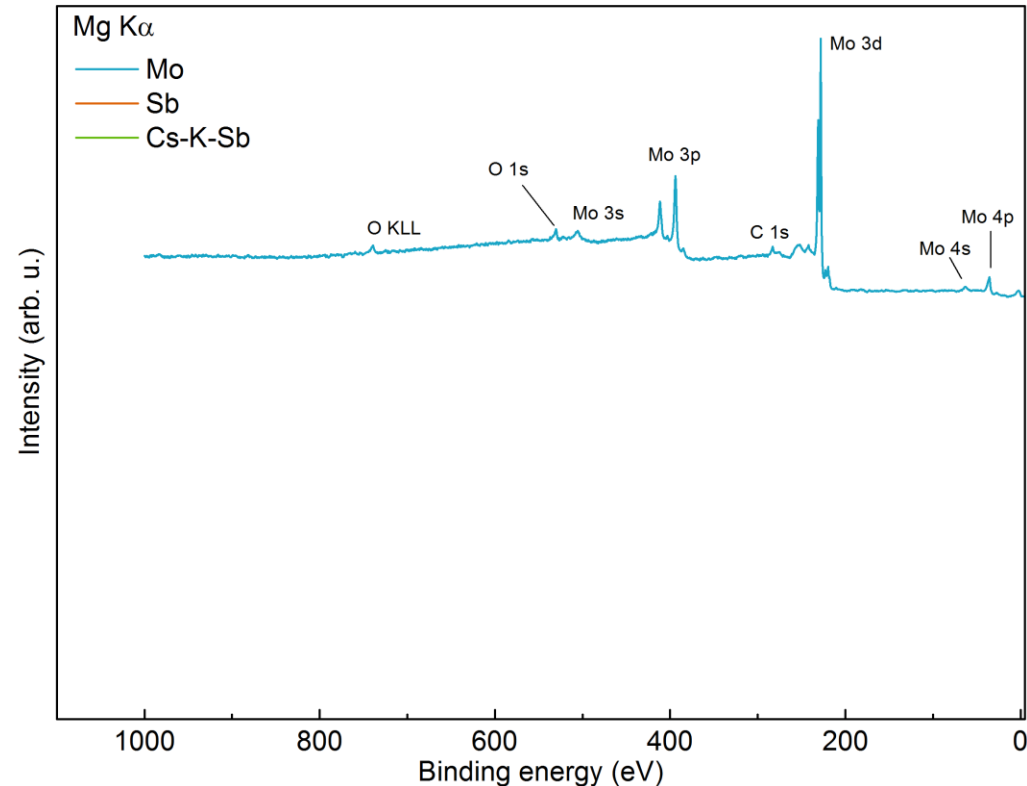
- X-ray photoelectron spectroscopy (XPS)
- Low Energy Ion Scattering (LEIS)

Now commissioned and ready for experiments :

- First Sample in April '15
- XPS system calibrated
- Both chambers in 10^{-10} mbar UHV

Sequential growth recipe

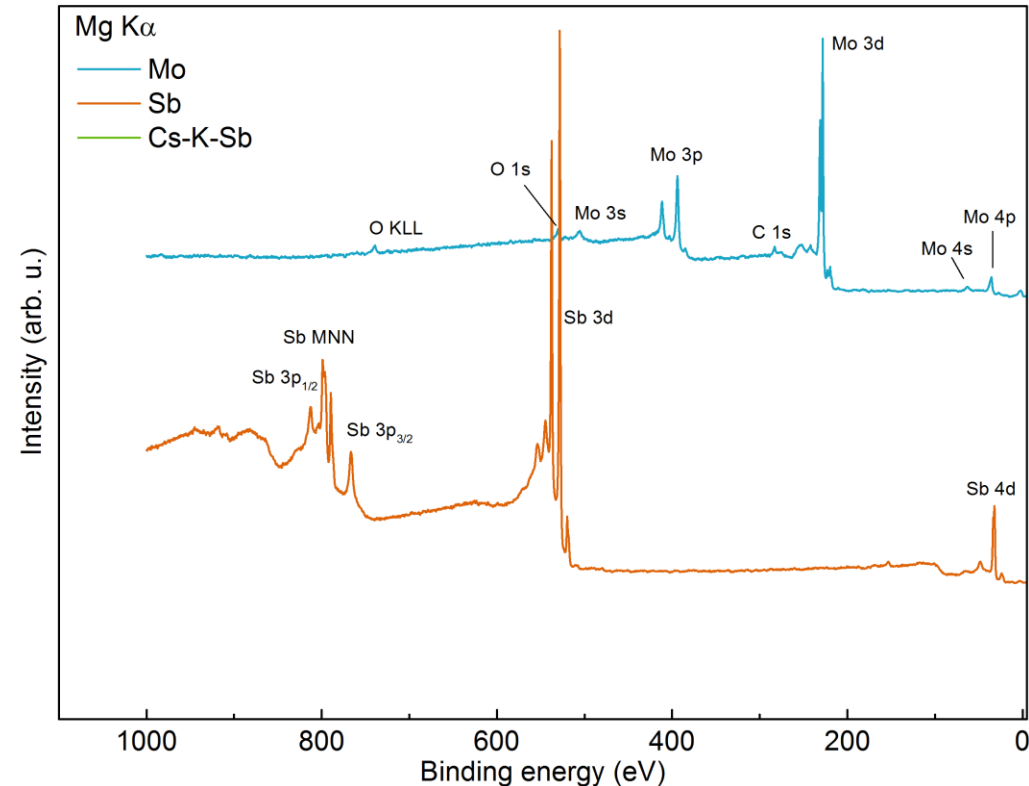
- Mo substrate, annealed at 450°C for 1h, sputter cleaned with Ar⁺, 3kV for 30min
- Substrate is relatively clean, O and C impurities probably from the material (99.9%)



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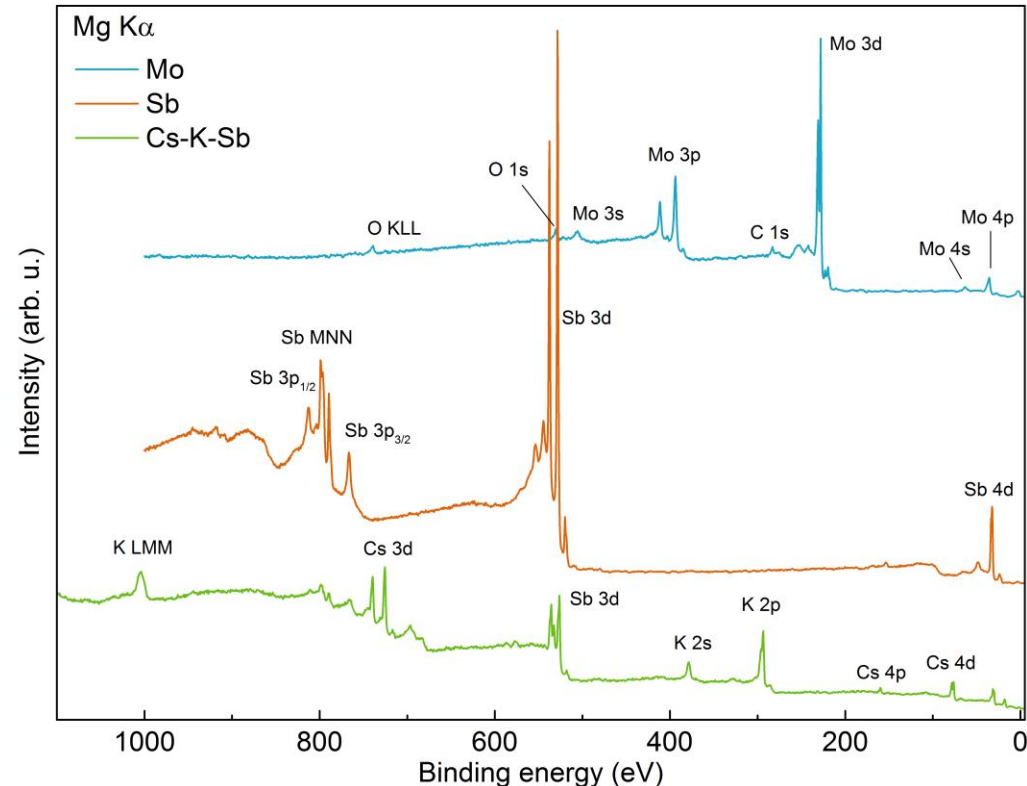
- Sb deposition at $1 \cdot 10^{-7}$ vapour pressure, 0.5 A/s
- Very clean Sb film



Sequential growth recipe

- Mo substrate, annealed at 450°C for 1h, sputter cleaned with Ar⁺, 3kV for 30min
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- Sb deposition at $1 \cdot 10^{-7}$ vapour pressure, 0.5 A/s
- Very clean Sb film
- K and Cs deposition from SAES dispensers
- Alkalis are hardly resolved in the mass spectrometer
- During K deposition, partial pressures of H₂O $2 \cdot 10^{-9}$ mbar, O₂ and CO $< 10^{-10}$
- Cs dispenser operated above its rated heating current to obtain a rate reading on quartz balance
- Cr and O impurities in the final Cs-K-Sb spectrum
- QE < 1%



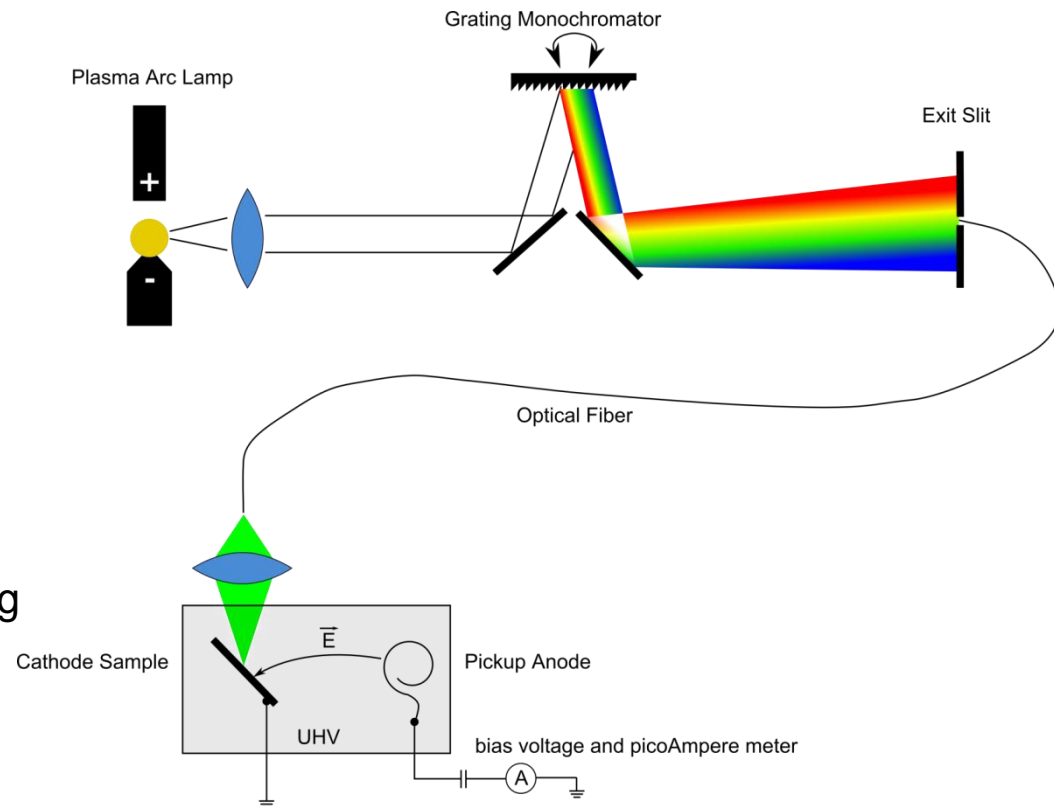
Requirements

- Broad band light source 400-700nm
- Spectral Intensity $\sim 1 \mu\text{W} / \text{nm}$
- High spectral resolution $< 1 \text{nm}$
- Sensitive current measurement
- 10 pA resolution, low noise

All commercially available, need to be set up carefully.

Probable solution :

300W Xe arc lamp
1/4m monochromator with 1200l/mm grating
Picoamperemeter, might need a lock in amplifier + chopper wheel

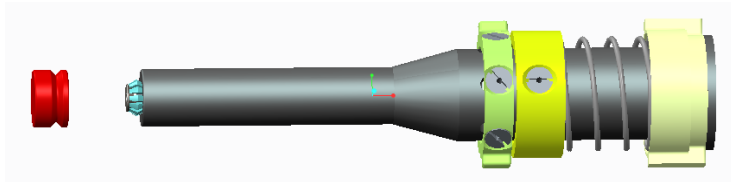


Next steps for cathode characterization :

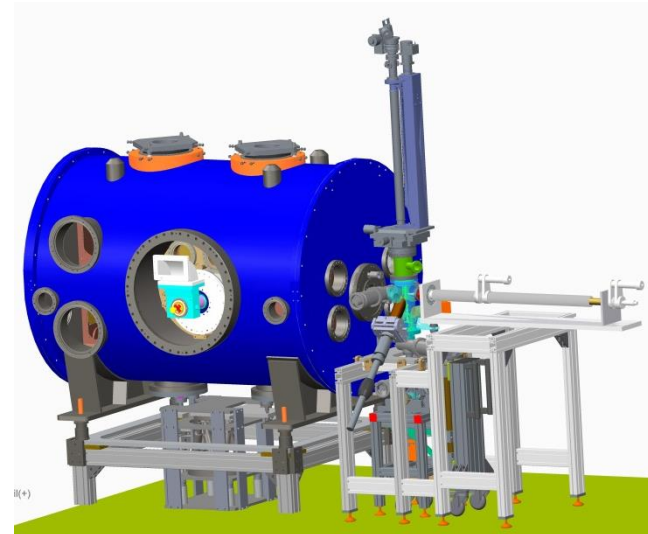
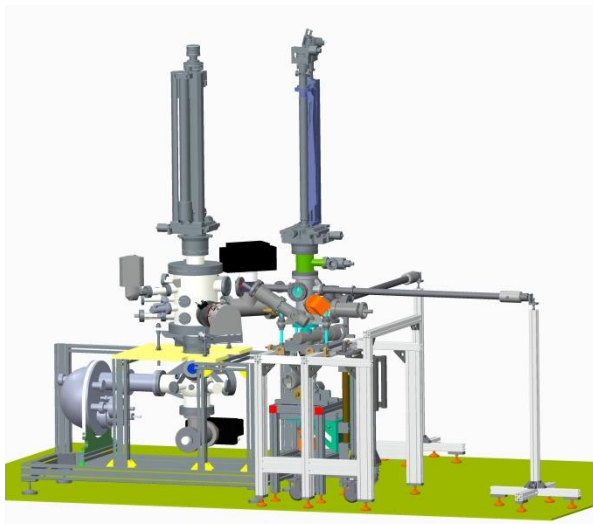
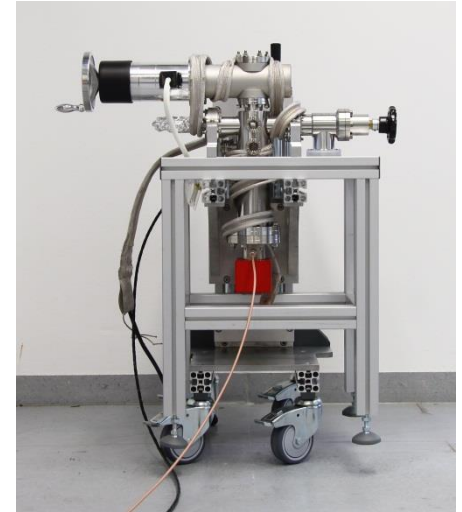
- Polished Mo substrates : characterize surface quality
- Influence of annealing and sputtering on surface quality
- Optimize Alkali deposition
 - Closer working distance of dispensers
 - Characterize K and Cs films separately
 - Determine purity
 - Determine good working parameters
- CsK₂Sb growth
 - Characterize purity and composition
 - Determine growth parameters for stoichiometric deposition
 - Learn more on influence of deposition parameters and composition on electronic structure and emission properties
- Evaluate alkali deposition from alkali chromates in a large crucible
 - Electron beam evaporators available
 - Co-deposition and sensitive rate control should be possible

Cathodes must be stored and handled in 10^{-11} mbar UHV!

- Vacuum suitcase is available. Vacuum $\sim 1 \cdot 10^{-11}$ mbar
- Stability with and without getter pump will be tested
- Design of plug holder is converged
- Tests of thermal contact are ongoing
- Disc springs inside the holder rod are too stiff, will test with softer ones



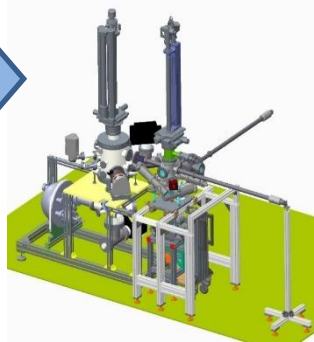
- Transfer system 1 (at Prep chamber) is ordered, commissioning in fall '15
- Engineering Design : Petr Murcek, Kerstin Martin



p 06-09-2015

06.2015

Photocathode Preparation and
assembly of Transfersystem #1

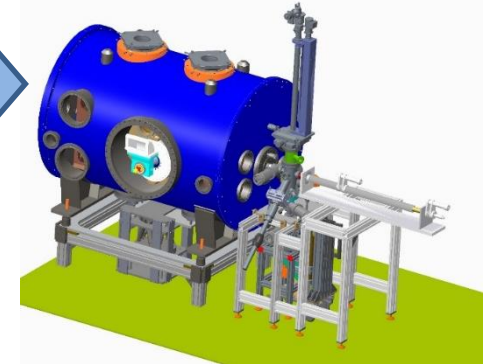


Fall 15

- Deposition studies
- Substrate preparation
- Set up transfer system 1

12.2015

1st CsK₂Sb photocathode
for Gun 1.0



Spring 16

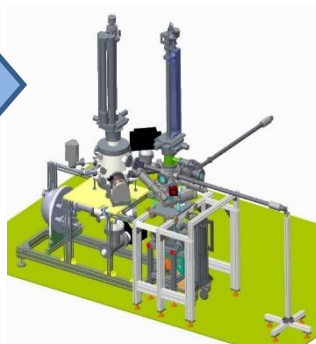
- Set up transfer system 2
- 1st CsK₂Sb photocathode
for Gun 1.0

06.2015

12.2015

03.2016

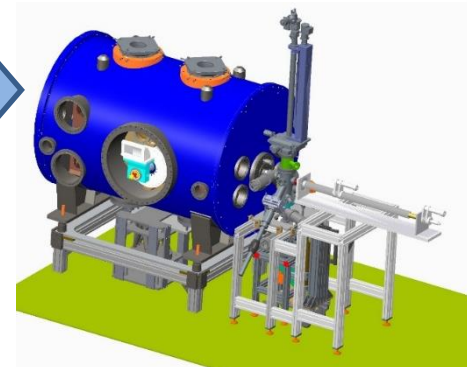
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Fall 15

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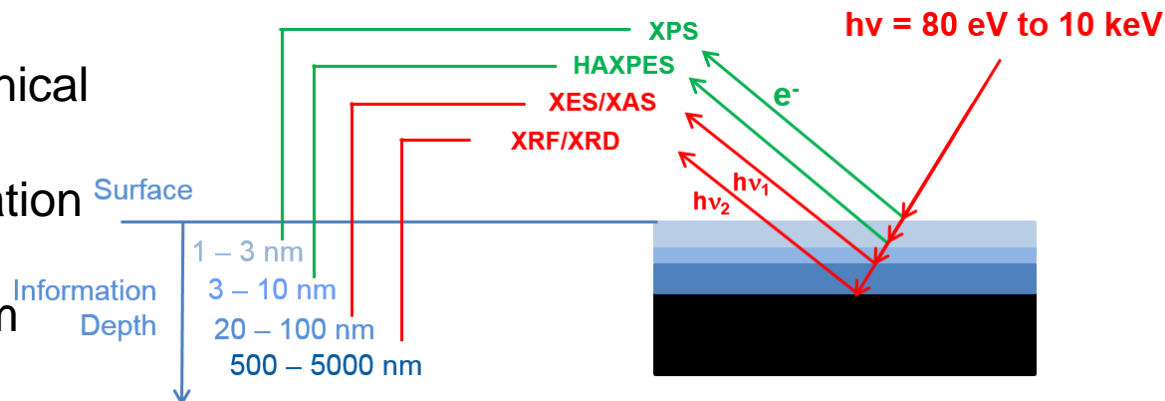


Spring 16

- Set up transfer system 2
- 1st CsK₂Sb photocathode
for Gun 1.0

bERLinPro meets **EMIL**

- Access to EMIL and technical aspects under discussion
- Unique methods combination
- Resolve chemistry and crystal structure in-system and for the same sample



THANK YOU FOR YOUR ATTENTION!

Many thanks to

- Julius Kühn, Thorsten Kamps
- Engineers : Petr Murcek (HZDR), Kerstin Martin, Daniel Böhlick
- Zihao Ding, John Smedley
- Susanne Schubert, Howard Padmore

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